NEMATODES PARASITIC IN WESTERN AUSTRALIAN FROGS

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Pp. 161–183; 33 *Text-figures*

NAT. HIST.
APR 1968
PRESENTED

BULLETIN OF
THE BRITISH MUSEUM (NATURAL HISTORY)
ZOOLOGY Vol. 16 No. 4
LONDON: 1968

THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), *instituted in* 1949, *is issued in five series corresponding to the Departments of the Museum, and an Historical series.*

Parts will appear at irregular intervals as they become ready. Volumes will contain about three or four hundred pages, and will not necessarily be completed within one calendar year.

In 1965 *a separate supplementary series of longer papers was instituted, numbered serially for each Department.*

This paper is Vol. 16, *No.* 4 *of the Zoological series. The abbreviated titles of periodicals cited follow those of the World List of Scientific Periodicals.*

World List abbreviation
Bull. Br. Mus. nat. Hist. (Zool.).

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TRUSTEES OF
THE BRITISH MUSEUM (NATURAL HISTORY)

Issued 3 *May,* 1968 *Price Ten Shillings*

NEMATODES PARASITIC IN WESTERN AUSTRALIAN FROGS

By W. GRANT INGLIS

SYNOPSIS

Five species of nematodes are reported from the rectum of frogs in southern Western Australia. Of these species *Aplectana flindersi* Johnston & Mawson, 1941 (which is referred to a new genus *Austracerca*) and *Raillietnema kartanum* Johnston & Mawson, 1941 were previously known from South Australia. The remaining three species are all new and referable to the genus *Parathelandros*. As a consequence the genus *Parathelandros* is reassessed and is here considered to contain seven species six of which are described, thus: *P. mastigurus* Baylis, 1930 (type species); *P. australiensis* (Johnston & Simpson, 1942) comb. nov.; *P. limnodynastes* (Johnston & Mawson, 1942) comb. nov.; *P. propinqua* (Johnston & Simpson, 1942) comb. nov.; *P. johnstoni* sp. nov.; *P. carinae* sp. nov.; *P. maini* sp. nov. This regrouping of the genus *Parathelandros* has necessitated the introduction of a new genus, *Skrjabinodon*, for seven species previously referred to the former genus, thus: *S. mabuyae* (Sandground, 1936) (type species); *S. anolis* (Chitwood, 1934); *S. apapillosus* (Koo, 1938); *S. mabuiensis* (Malan, 1939); *S. megalocerca* (Skrjabin, 1916); *S. oedurae* (Johnston & Mawson, 1947); *S. scelopori* (Caballero, 1938).

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INTRODUCTION

THE parasites on which this report is based were collected in Western Australia from newly trapped frogs; from frogs collected by Professor A. R. Main, Western Australia University; and from some frogs in the collections of the Western Australian

Museum. This combination of sources has enabled me to delimit the species of parasites on the basis of very good material so that it was then possible to recognize the same species fairly easily when they were obtained from long preserved host specimens. In this way it was possible to cover a wider host and geographical range (Text-fig. 1) than would otherwise have been possible.

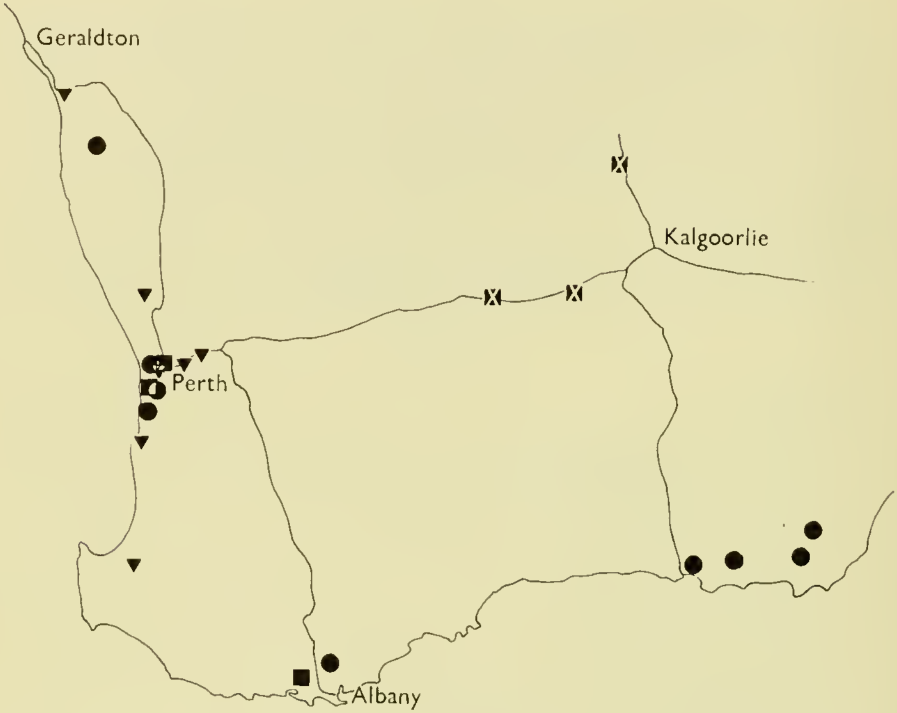


FIG. 1. Outline map of southwest corner of Western Australia from about Geraldton in the north to Esperance in the east, showing distribution of *Parathelandros* species. *P. johnstoni*—squares; *P. maini*—circles; *P. carinae*—triangles. The crossed squares represent the records of *P.*(?) *johnstoni* from Yellowdine, Moorine Rock and Comet Vale reading from left to right on the map. The lines indicate some of the major roads of the area.

A total of 197 frogs was examined, of which 84 were parasitized by rectal nematodes. In addition a few were parasitized by a cestode in the intestine, more often by lung flukes and in a very few cases an acanthocephalan was recovered from the intestine. There was no observable relationship between the occurrence of any of these parasites and the rectal parasites. The remainder of this paper is based on the rectal parasites alone.

In addition to the Western Australian parasites, similar parasites from hosts in the eastern part of Australia were studied from the collections of the University of Adelaide. Holotypes and some paratypes of all new species are deposited in the collections of the Western Australian Museum, Perth. Other paratypes and specimens are in the collections of the British Museum (Natural History).

TAXONOMIC RESULTS

The majority of the 2,000 (approximately) parasite specimens collected in Western Australia are referable to the oxyurid genus *Parathelandros*, but two cosmocercoid species, previously known from South Australian hosts, were also found and are described first.

COSMOCERCIDAE Railliet, 1916

Austracerca flindersi (Johnston & Mawson, 1941) comb. nov.

(Text-figs. 2-4)

Material studied. 1 ♂, Holotype ex *Hyla jervisiensis*, Kangaroo Island, South Australia. Specimen in South Australian Museum.

1 ♂, 1 ♀. ex rectum of Hyla *cyclorhyncha*, 14 miles east of Esperance, Western Australia. From host collected by Dr. G. M. Storr on 9th December, 1959.

1 ♂, 1 ♀ ex rectum of *Helioporus australiacus*, Boya, Western Australia. From host collected by Prof. A. R. Main on 22nd April, 1954.

2 ♀, 1 larva. ex rectum of *Helioporus psammophilus*, Dongara, Western Australia.

Measurements (mm.).

Males. Body length: 2·0; 2·6. Body breadth: 0·16; 0·17. Oesophagus length: 0·38; 0·41. Distance of excretory pore from anterior end of body: 0·24; 0·27. Length of tail: 0·23; 0·26. Length of spicules: 0·12; 0·12. Length of gubernaculum: 0·13; 0·16.

Females. Body length: 2·9; 4·9. Body breadth: 0·21; 0·24. Oesophagus length: 0·66; 0·67. Distance of excretory pore from anterior end of body: 0·28; 0·31. Length of tail: 0·61; 1·12. Distance of vulva from anterior end of body: 0·29; 0·36. Eggs: 0·098–0·100 (spherical).

There are narrow lateral alae on the body on both sexes and there are no papillae on the general surface of the body. The oesophagus has the usual tri-valvulate posterior oesophageal bulb. The excretory pore lies well anterior to the posterior end of the oesophagus.

The mouth opening is bounded by three, shallow lips of which the dorsal carries two stout, double outer papillae and each ventro-lateral lip carries a similar papilla ventrally and a smaller papilla laterally associated with the lateral amphids. There appear to be two small papillae on the inner edge of each lip, but it is impossible to be sure although two nerve tracts are certainly present (Text-fig. 4). The anterior end of the oesophagus is modified as a chamber with very thick, sclerotized walls, into which project three distinct onchia (Text-fig. 4).

The male tail is simple, without alae, and all the papillae are sessile, although some are well developed. There are two pairs of ventro-lateral pre-cloacal papillae; three pairs arranged in a triangle lying at the level of the cloacal opening; five papillae on the anterior lip of the cloacal opening, one of which is median (Text-fig. 3); and there are six pairs of post cloacal papillae of which three pairs are almost wholly ventral, one pair is lateral about half way along the tail, and two pairs lie just anterior to the terminal spike (Text-fig. 2).

The spicules are very slim and needle-like while the gubernaculum is very prominent with lateral processes near its anterior end so that it is dagger-shaped in ventral view (Text-figs. 2, 3).

The female tail is long and stout, and the reproductive system is doubled.

Discussion. The specimens described above are indistinguishable from those described by Johnston & Mawson (1941) as *Aplectana flindersi* and are referred to that species. This species is however very different from the more typical *Aplectana* Railliet & Henry, 1916 species particularly in the presence of the oesophastome with three well developed onchia and in the small spicules associated with the very large gubernaculum. I therefore propose to refer the species to a new genus which may be diagnosed thus:

Austracerca gen. nov.

Cosmocercidae: Cosmocercinae: no papillae on body surface; lateral alae present; mouth bounded by three distinct lips; oesophastome distinct cavity into which project three onchia. Male: spicules slim; gubernaculum large and massive; no caudal alae; caudal papillae simple and sessile. Female: vulva anterior to posterior end of oesophagus.

Type species: *Aplectana flindersi* Johnston & Mawson, 1941.

Hosts and geographical distribution: *Hyla jervisiensis*, Nr. Esperance, Western Australia; *Helioporus australiacus*, Boya, Western Australia; *Helioporus psammophilus*, Dongara, Western Australia.

Raillietnema kartanum Johnston & Mawson, 1941

(Text-figs. 5-8)

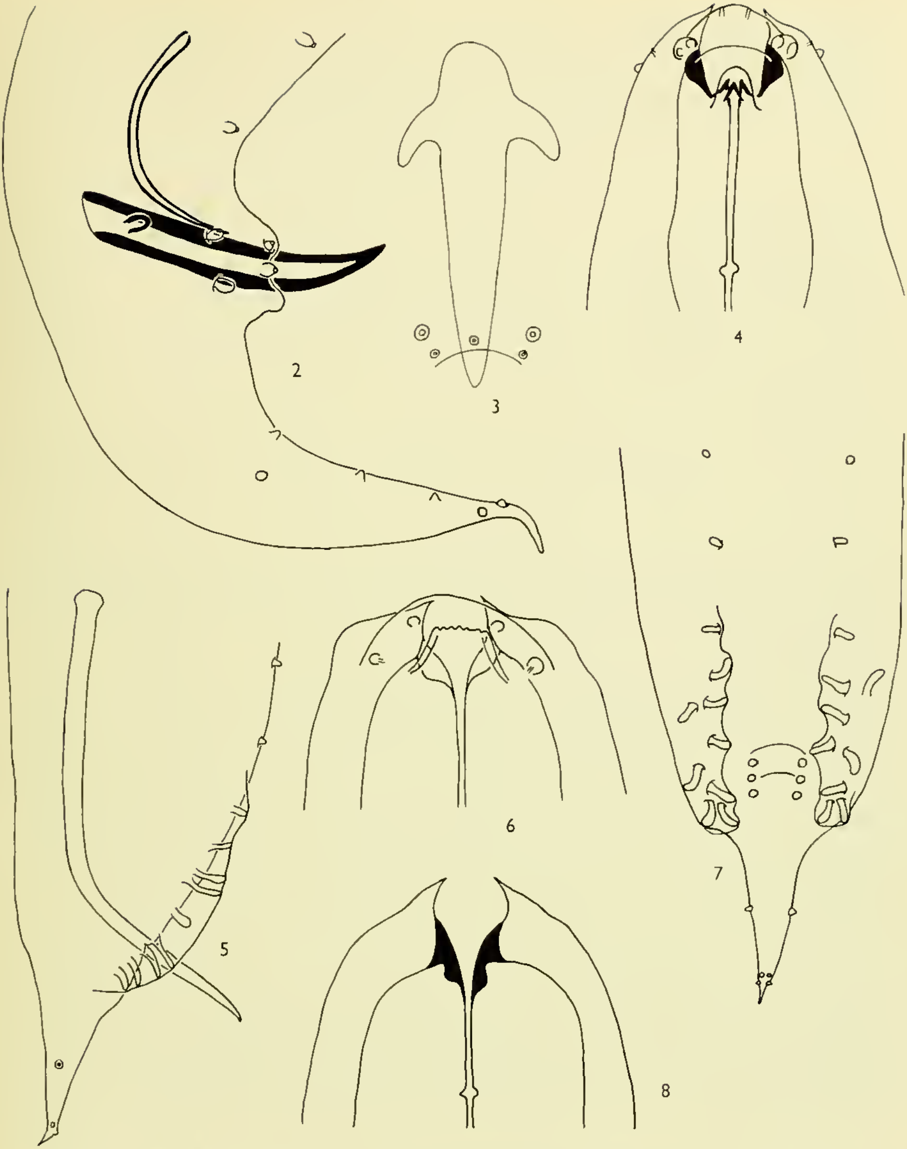
Material studied. 1 ♂, Holotype. ex *Hyla jervisiensis*, Kangaroo Island, South Australia. Specimens in South Australian Museum.

1 ♂, 1 ♀ ex rectum of *Hyla moorei*, Bolganup Dam, Porongorup Range, Western Australia. Host collected by Dr. G. M. Storr on 14th December, 1959.

2 ♀. ex rectum of *Helioporus eyrei*, Chidlows, Western Australia.

Measurements (mm.).

Male. Body length: 4·0; Body breadth: 0·23; Oesophagus length: 0·57; Distance of excretory pore from anterior end of body: 0·36; Length of tail: 0·13; Length of spicules: 0·23.



FIGS. 2–8. *Austracerca flindersi*. 2. Lateral view of male tail. 3. Ventral view of gubernaculum and papillae on anterior lip of cloacal opening. 4. Dorsal view of head showing detail of buccal cavity. 5–8. *Raillietnema kartanum*. 5. Lateral view of male tail. 6. Dorsal view of head. 7. Ventral view of male tail showing distribution of caudal papillae. 8. Head in optical section showing shape of cuticular thickening at anterior end of oesophagus.

Female. Body length: 6·1; Body breadth: 0·40; Oesophagus length: 0·66; Distance of excretory pore from anterior end of body: 0·41; Length of tail: 0·33; Distance of vulva from anterior end of body: 3·4; Size of eggs: 0·062–0·066 (spherical).

There are narrow lateral alae in both sexes and there are no papillae on the general surface of the body. The oesophagus is typical with the usual tri-valvulate posterior bulb. The excretory pore lies about the middle of the oesophagus length in both sexes.

The mouth opening is bounded by three lips of which the dorsal bears two single outer papillae while each ventro-lateral lip carries a single ventro-lateral papilla and a small papilla associated with the lateral amphids. There are six prominent papillae arranged in pairs on the inner edge of each lip (Text-fig. 6). The anterior end of the oesophagus bears a region of thickened cuticle which projects anteriorly to line each lip (Text-fig. 8). There are no tooth-like structures at the anterior end of the oesophagus.

The posterior end of the male bears thick, ventro-lateral alae supported by nine pairs of pedunculate papillae arranged roughly in two rows; an inner more ventral row of four and an outer of three. The remaining two pairs occur side by side at the posterior end of the alae (Text-fig. 7). Anterior to the alae are two pairs of ventral sessile papillae while there are three pairs of similar, but less prominent, papillae flanking the cloacal opening. The tail bears three pairs of small, sessile papillae of which two lie close together just anterior to the small terminal spike, while the third pair is lateral in position about two thirds of the length of the tail posterior to the cloacal opening.

The spicules are stout, equal in length, non-alate, identical in structure and taper evenly posteriorly (Text-fig. 5). There is no gubernaculum.

The female tail is relatively long and stout and the reproductive system is doubled.

Discussion. The specimens described here are morphologically indistinguishable from *Raillietnema kartanum* Johnston & Mawson, 1941 from *Hyla jervisiensis* in South Australia of which I have studied the holotype. Any apparent differences can be attributed to differences in the fixation of the specimens or can be looked on as falling well within the normally expected range of variation.

Johnston and Mawson (*loc. cit.*) comment on the fact that their specimens are not wholly typical of the genus *Raillietnema* while Skrjabin, Schikhobalova & Lagodovskaya (1961) refer the species to *Oxysomatium* (S.L.) because of this uncertainty. However the only apparently marked difference between the Australian specimens and typical *Raillietnema* species is the absence of a gubernaculum. But the genus *Raillietnema* is relatively poorly known and, while later study may demonstrate other differences between *R. kartanum* and other species of the genus, I treat this Australian species as a member of *Raillietnema*, at least provisionally.

OXYURIDAE Cobbold, 1864

Parathelandros Baylis, 1930

Since 1930 when Baylis erected the genus *Parathelandros* for *P. mastigurus* three further species have been referred to the genus, thus: *P. anolis* Chitwood, 1934;

P. oedurae Johnston & Mawson, 1947 and *P. scelopori* Caballero, 1938. In addition Skrjabin, Schikhobalova & Lagodovskaya (1960) refer a further four species, previously referred to other genera, to *Parathelandros*, thus: *Pharyngodon bassii* Walton, 1940; *Ph. mabuiensis* Malan, 1939; *Ph. mabuyae* Sandground, 1936 and *Oxyuris megalocerca* Skrjabin, 1916; while Read & Amrein (1953) refer *Ph. apappillosus* Koo, 1938 and *Ph. medinae* Calvente, 1948 to the genus.

The genus itself has been accepted as distinct by most authors except Yamaguti (1961) who treats it as indistinguishable from *Pharyngodon* Diesing, 1861. It can be said immediately, in anticipation of the descriptions which follow, that *Parathelandros* warrants recognition as a distinct genus. The species described below all occur in Australian hosts and because of their morphological uniformity it is doubtful if the species referred to the genus by authors other than Baylis can be considered con-generic with *P. mastigurus*. This is discussed in detail later and I shall first describe the anatomy of the six species which appear to be definitely congeneric with *P. mastigurus*, of which three are here described as new and two have not previously been recognized as members of the genus. A seventh species, of which I have not seen specimens, is referred to the genus on the basis of a published description.

MORPHOLOGY. The heads bear four large, single, dorso- and ventro-lateral papillae and a pair of small, slightly finger-like lateral amphids (Text-figs. 10–12, 16). There may be six small papillae of the inner circle present (see particularly Text-fig. 16) but I cannot be certain. The mouth opening is bounded by three major lip lobes each of which is divided into two, largely cuticular, subsidiary lobes. The extent of this division into lobes and the degree to which the lips are set-off from the head varies somewhat but the differences are not constant from species to species, as recognized on other characters, and appear to reflect the extent to which the mouth is open or shut (Text-figs. 11, 12, 16). The mouth leads in to a shallow cheilostome which is triangular in transverse section. The lumen at the anterior end of the oesophagus is expanded to form a cup-like cavity into which project three apparently wholly cuticular onchia (Text-figs. 10, 11; see Inglis, 1962). The degree of development of the onchia, as with the lip lobes, varies from specimen to specimen but this also appears to reflect muscular contraction rather than a constant difference between the species.

The oesophagus is typically oxyurid with a prominent, tri-valvulate posterior bulb (Text-figs. 14, 15, 17). Single lateral alae which are present on both sexes, start anteriorly about the middle of the oesophagus length as stout swellings (Text-fig. 17) which narrow tangentially and widen laterally more posteriorly. The width of the alae varies considerably from species to species, particularly when male specimens are compared. The tail in both sexes ends posteriorly in a very long, slim spike (Text-fig. 13).

MALE. The male tail narrows rapidly, posterior to the cloacal opening, to form a terminal spike (Text-figs. 13, 20, 21, 26). The lateral alae stop slightly posterior to the cloacal opening after constricting sharply (Text-figs. 18, 20, 21, 26). The region round the cloacal opening is raised as a genital cone on which there are two pairs of papillae, one pair anterior to the cloacal opening and one pair posterior. The relative sizes of these papillae vary from species to species. In some species there is a median post-cloacal spherical swelling or posteriorly directed process which lies between the more posterior pair of papillae (Text-figs. 19, 23–25). A third pair of papillae lie on the ventral surface of the tail about the posterior limit of the lateral alae. These papillae frequently arise from a common basal platform, or swelling, and are usually of a rosette type, as are some of the cloacal papillae. A single, frequently poorly sclerotized spicule is present and a small, insignificant gubernaculum supports the posterior lip of the cloacal opening in most specimens. Phasmids have been seen on some specimens lying roughly mid-way between the genital cone and the pair of tail papillae.

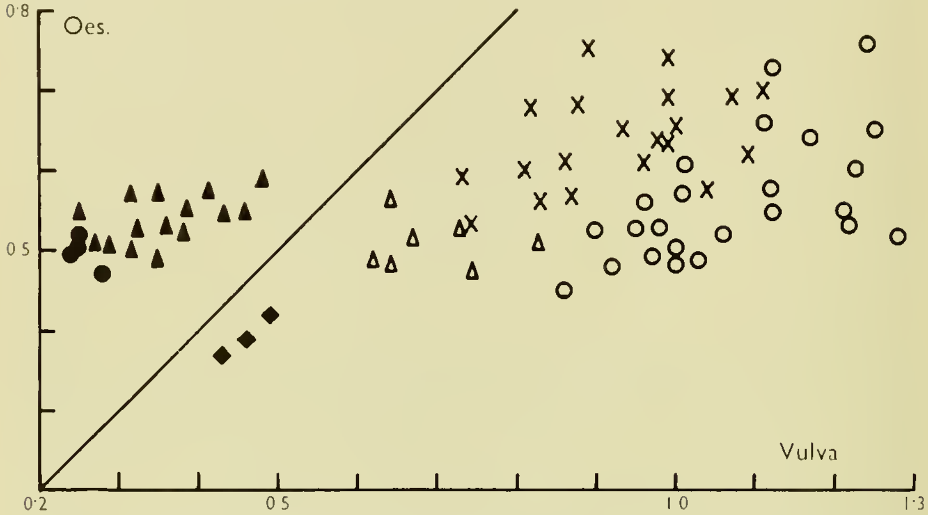


FIG. 9. Scatter diagram plotting distance (in mm.) of vulva from anterior end of body against length of oesophagus, in species of *Parathelandros*. *P. mastigurus*—solid circles; *P. maini*—solid triangles; *P. australiensis*—solid diamonds; *P. limnodynastes*—empty triangles; *P. johnstoni*—crosses; *P. carinae*—empty circles. Note particularly the extent to which the longer specimens of *P. johnstoni* and shorter specimens of *P. carinae* overlap and the separation of *P. limnodynastes* and *P. johnstoni* which may simply reflect the difference in size of the specimens studied (see text). Note that this scatter diagram includes some specimens not listed in the measurements given at the end of the taxonomic section of this paper.

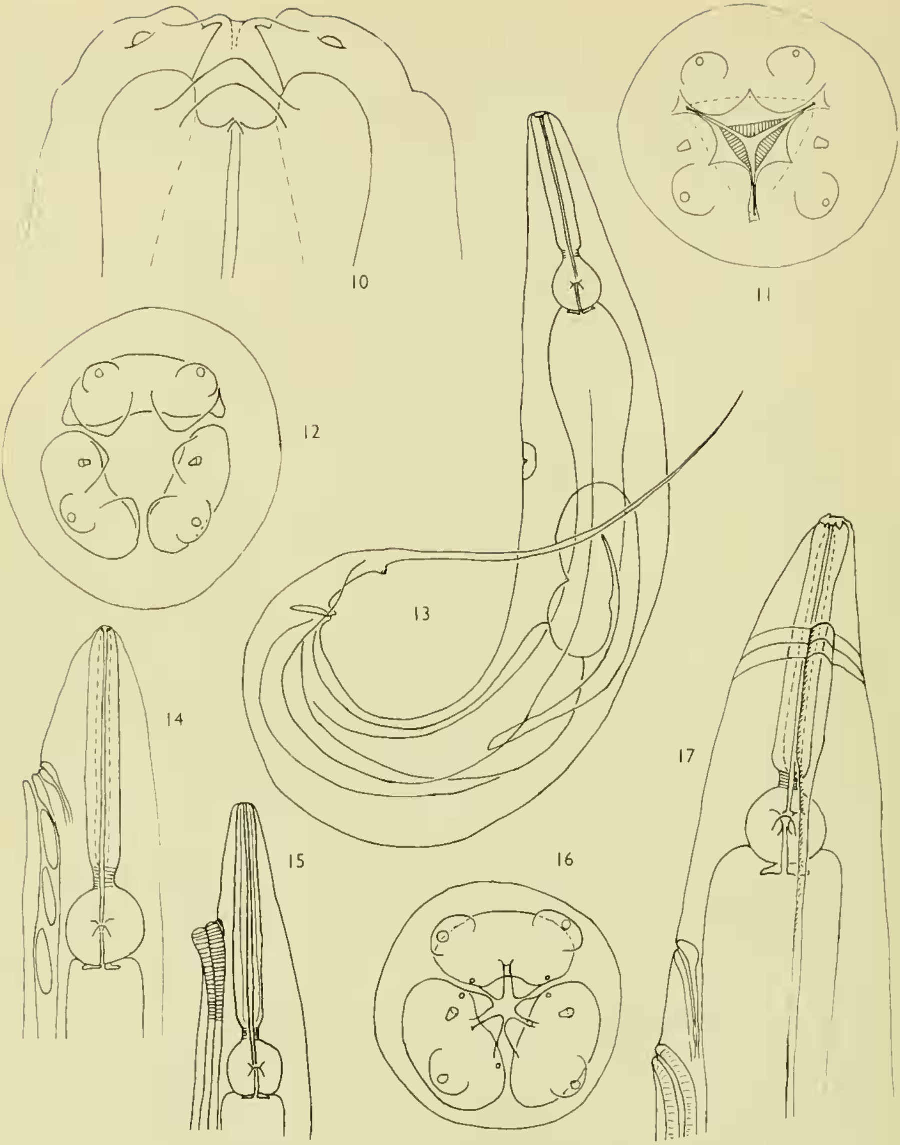
In some male specimens there is a swollen region on the ventral surface of the body anterior to the cloacal opening (Text-fig. 32). This feature is not constant in occurrence and, as it occurs most commonly in specimens recovered from host specimens which had been stored for some time, it is almost certainly a fixation artefact.

FEMALE. The vulva, which can open anterior to, on a level with the posterior end of, or posterior to the oesophagus, is very prominent and leads into a stout, muscular vagina (Text-figs. 14, 15, 17). The vagina in turn leads to a somewhat clubbed chamber from which two uteri arise. One uterus runs posteriorly and the other almost immediately runs anteriorly. The eggs are elongate, spindle-shaped with a latero-terminal operculum and are segmented *in utero*. There is a small, ovoid swollen region just posterior to the anus.

DELIMINATION OF SPECIES. The specimens, particularly the males, are small but the species from Western Australian hosts, at least, can be distinguished fairly readily by the width of the lateral alae and the position of the vulva. It is not, however, possible to identify specimens from other areas with certainty on these criteria if their geographical origins are unknown and even with Western Australian specimens it is advisable to study the cloacal region of the males in ventral view.

All the species recognized here can be distinguished by some combination of the characters discussed below.

1. The position of the excretory pore relative to the posterior end of the oesophagus enables three groups to be distinguished, one in which the excretory pore lies about the middle of the oesophagus length, one in which it lies close to the posterior end of the oesophagus and one in which the excretory pore is relatively far posterior to the posterior end of the oesophagus.
2. The position of the vulva relative to the posterior end of the oesophagus falls into three groups corresponding to the groups formed on the basis of the excretory pore. In general the excretory pore and the vulva lie close together with the former slightly anterior to the latter, and the vulva is easily seen because it projects slightly above the surrounding body surface (Text-figs. 14–15). The possibility of confusing these three divisions occurs with immature or small specimens of the groups in which the adult vulva is posterior to the posterior end of the oesophagus. In such specimens the vulva lies relatively more anterior than it does in adult or large specimens (Text-fig. 9).
3. The breadth of the lateral alae in both sexes forms two groups in one of which the alae are narrow while in the other they are very wide. This character is much more easily used than it may appear at first sight because the wide alae particularly on the males are very prominent being together equal in width to the width of the body (Text-figs. 18, 21, 26), and this difference can be easily seen even under a fairly low power stereoscopic microscope. In male specimens the alae can cause great difficulty in rolling specimens to obtain a ventral view of the cloacal region.
4. The size of the genital cone and associated papillae on the males is particularly useful and forms the most characteristic feature of the various species. Two major groups can be recognized, one in which the papillae are prominent and there is no post-cloacal process and one in which such a process is present and the papillae are small. In addition the relative sizes of the cloacal papillae vary from species to species and some of the papillae may be of a rosette-type (Text-figs. 18, 20, 26). The post-cloacal lobe itself may be of two major forms, one in which it is a spherical ball-like structure which may be smooth or may be covered by small cuticular



FIGS. 10–17. 10. *P. maini*: dorsal view of head. 11. *P. carinae: en face* view of head; cross-hatched regions are teeth at anterior end of oesophagus. 12. *P. carinae: en face* view of head to illustrate difference in appearance caused by contraction of musculature. 13. *P. limnodynastes:* lateral view of whole male to show general facies of the genus. 14. *P. maini:* anterior end of body. 15. *P. mastigurus:* anterior end of body, compare with *P. maini*. 16. *P. carinae*: *en face* view of head showing further variation in appearance. 17. *P. johnstoni:* anterior end of body. Note how the alae start as broad low swellings and then narrow about the anterior limit of the posterior oesophageal bulb

granulations, and one in which it is a posteriorly directed triangular process (Text-figs. 19, 23–25).

On the basis of these characters the following six species can be distinguished: *P. mastigurus* (Type species); *P. australiensis* and *P. limnodynastes* (new combinations); *P. maini*, *P. carinae* and *P. johnstoni* (new species).

Unless qualified all host and locality records are new. Numbers refer to material in collection of the University of Adelaide.

Parathelandros mastigurus Baylis, 1930

(Text-figs. 15, 18, 19, 27, 28).

HOSTS AND LOCALITIES. *Hyla caerulea:* Neighbourhood of Townsville, Queensland (Here selected as type host and locality; recorded by Baylis, 1930). Burnett River, Queensland (U.A. 1/1911; U.A. HC2341); Sydney, New South Wales (U.A. HC2336; U.A. HC2344; U.A. HC8).

Hyla gracilis: Neighbourhood of Townsville, Queensland (recorded by Baylis, 1930).

Bufo marinus: Brisbane, Queensland (from class material: U.A. HC9/56).

This species is well described by Baylis (1930) and the head is described by Inglis (1963).

This species is characterized by the excretory pore and vulva opening about the middle of the oesophagus length and by the possession of very wide alae. The cloacal cone is small with small papillae of which the more posterior pair is very small while the anterior pair is prominent, pedunculate and rosette-type. A post-cloacal lobe is present which is long, smooth, triangular in outline and posteriorly directed. The caudal papillae do not arise from a distinct common base.

Parathelandros australiensis (Johnston & Simpson, 1942) comb. nov.

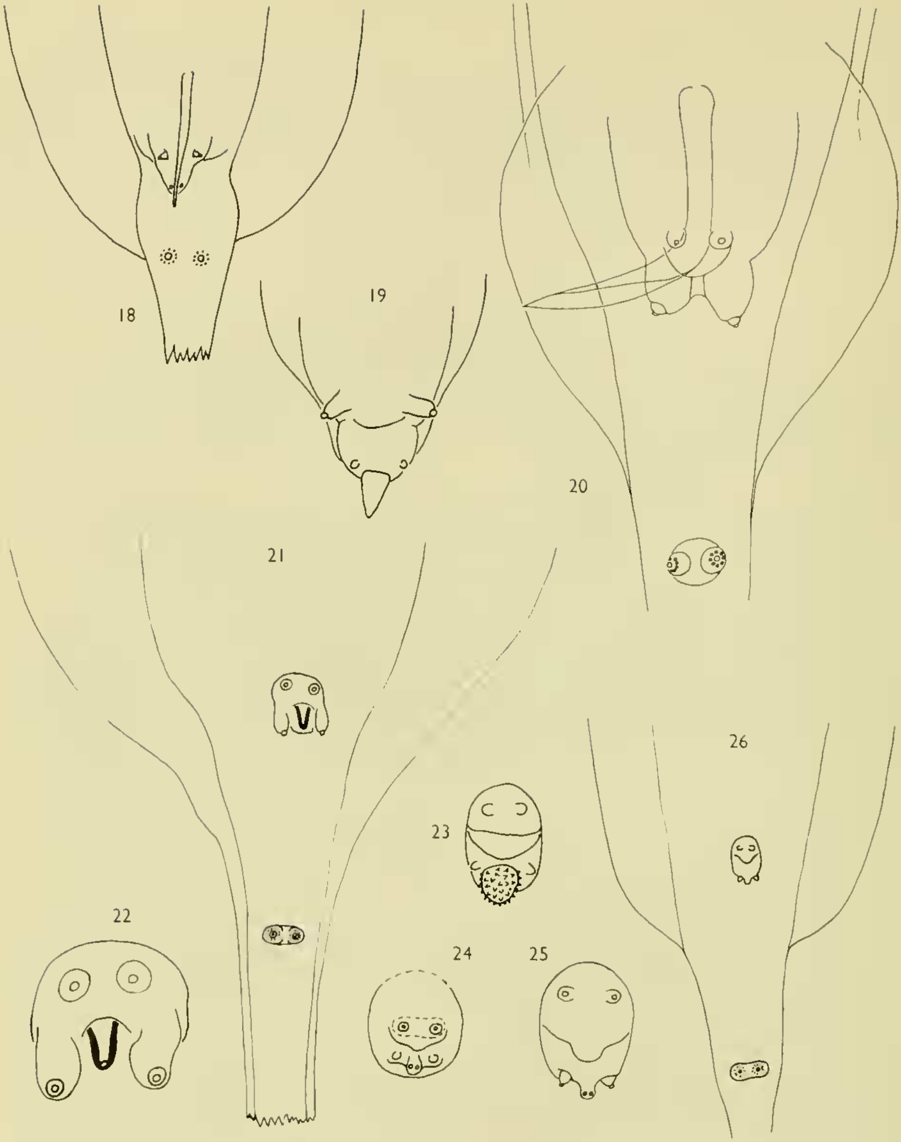
(Text-figs. 23, 33).

Cosmocerca australiensis Johnston & Simpson, 1942.

HOSTS AND LOCALITIES. *Limnodynastes dorsalis:* from vicinity of Adelaide, South Australia. (Type host and locality; recorded by Johnston & Simpson, 1942);

Limnodynastes fletcheri: Chowilla Station, on River Murray, S.A. (U.A. A1401; U.A. A1402).

This species was described and named on the basis of females which, as Johnston & Simpson (1942) point out, made classification difficult. The specimens I have seen agree with the published description. Although the very broad lateral alae were not mentioned, they are frequently not prominent on females. In spite of the difficulty mentioned above in identifying females in the absence of males, my experience with Western Australian species suggests that it is unlikely that there will be another South Australian species with very broad alae and a vulva opening slightly posterior to the posterior end of the oesophagus.



FIGS. 18–26. Ventral views of cloacal regions of *Parathelandros* males. 18, 19. *P. mastigurus:* general view showing breadth of alae and detail of cloacal cone respectively. 20. *P. carinae:* showing particularly the bursa-like modification of the alae in the cloacal region and the very large size of the more posterior pair of cloacal papillae relative to the anterior pair. 21, 22. *P. johnstoni:* general view of the cloacal region showing

This species is, therefore, distinguished by the excretory pore and vulva opening slightly posterior to the posterior end of the oesophagus and in possessing very broad lateral alae particularly in the male. The cloacal cone is small with small cloacal papillae of equal size. A post-cloacal lobe is present which is spherical and bears cuticular granulations. No gubernaculum has been seen in any of the specimens examined. The caudal papillae rise from a common base.

Parathelandros limnodynastes (Johnston & Mawson, 1942) comb. nov.

(Text-figs. 13, 31).

Pharyngodon limnodynastes Johnston & Mawson, 1942.

Hosts and localities. *Limnodynastes dorsalis:* Tailem Bend, South Australia (Type host and locality; recorded by Johnston & Mawson, 1942; host recovered from a tiger snake, *Notechis scutatus*); Coromandel Valley, Mt. Lofty Range, South Australia (from class material: U.A. HC2366); Magill, Adelaide, South Australia (class material: U.A. HC3176).

The original description of this species was based on female specimens so that, as with *P. australiensis*, its allocation is difficult. Nevertheless the description given by Johnston & Mawson (1942) agrees well with the specimens I have seen. I have also studied the type specimen, a female, and there is nothing to distinguish it from the other female specimens I have seen.

In this species the excretory pore and vulva open fairly close to the posterior end of the oesophagus and the lateral alae are broad. The cloacal cone is large with large pedunculate papillae which are equal in size. There is no post-cloacal lobe and the caudal papillae arise from a common base. No gubernaculum has been seen.

Parathelandros johnstoni sp. nov.

(Text-figs. 21, 22, 30)

Hosts and localities (all in Western Australia). *Helioporus eyrei:* Bibra Lake, (Type host and locality). Sheepwash Creek (17 miles north east from Denmark on the Mt. Barker road); Butlers Swamp, Lake Claremont, Perth; Beechina; Swanview.

Neobatrachus pelobatoides: Caversham.

Lymnodynastes dorsalis: Bibra Lake; Bayswater Road, Nr. Garratt Road Bridge, Perth.

Neobatrachus centralis: Yellowdine; Moorine Rock; Comet Vale (all records slightly doubtful, see discussion below).

This species is characterized by the excretory pore and vulva opening relatively close to the posterior end of the oesophagus and by the possession of wide lateral

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wide lateral alae and the smaller cloacal papillae relative to *P. carinae*, and detail of the cloacal cone. 23. *P. australiensis:* detail of cloacal cone showing, slightly diagrammatically, the denticulate spherical post-cloacal lobe. 24–26. *P. maini:* 24, 25 Detail of cloacal cone showing variation in appearance. Note the double(?) papilla on the post-cloacal lobe. 26. General view showing wide lateral alae.

alae. The cloacal cone is small with medium sized cloacal papillae which do not arise as distinct structures. There is no post-cloacal lobe and the caudal rosette papillae arise from a common platform. The spicule and gubernaculum tend to be poorly developed and may even be absent in some specimens.

This species is very similar to *P. limnodynastes*. The differences between them are slight but consist of the smaller and slimmer spicule; the cloacal papillae, which never appear to stand out distinctly from the smallish cloacal cone; and the vulva which lies relatively further posterior to the oesophagus (Text-fig. 9). The similarities to *P. limnodynastes* are very marked but the slight differences are very consistent so I will treat this species as distinct, at least until more specimens of *P. limnodynastes* are available for study.

The specimens from *Neobatrachus centralis* are in very poor condition and it is difficult to decide, in view of what I say above, whether they are *P. maini* or *P. limnodynastes*.

Parathelandros carinae sp. nov.

(Text-figs. 11, 12, 16, 20, 29, 32)

HOSTS AND LOCALITIES (all in Western Australia). *Heleioporus albopunctatus:* Bakers Hill, Northam (Type host and locality) Beechina (31 miles from Perth on road to Northam).

Heleioporus australiacus: Middle Swan.

Heleioporus psammophilus: Near Geraldton (257 miles from Perth); Beechina; 161 mile peg on Augusta Road from Perth.

Heleioporus eyrei: Beechina; Bushmead.

Neobatrachus pelobatoides: Wannamal.

This species is characterized by the excretory pore and vulva opening far posterior to the posterior end of the oesophagus and by the possession of very narrow lateral alae.

The alae expand in the cloacal region of the male to form a bursa. The cloacal cone and papillae, particularly the more posterior pair, are very large. The spicule and gubernaculum are very distinct in all the specimens studied.

This species is the largest of all those studied and is easily recognized by the bursa-like modification of the caudal alae (Text-fig. 20).

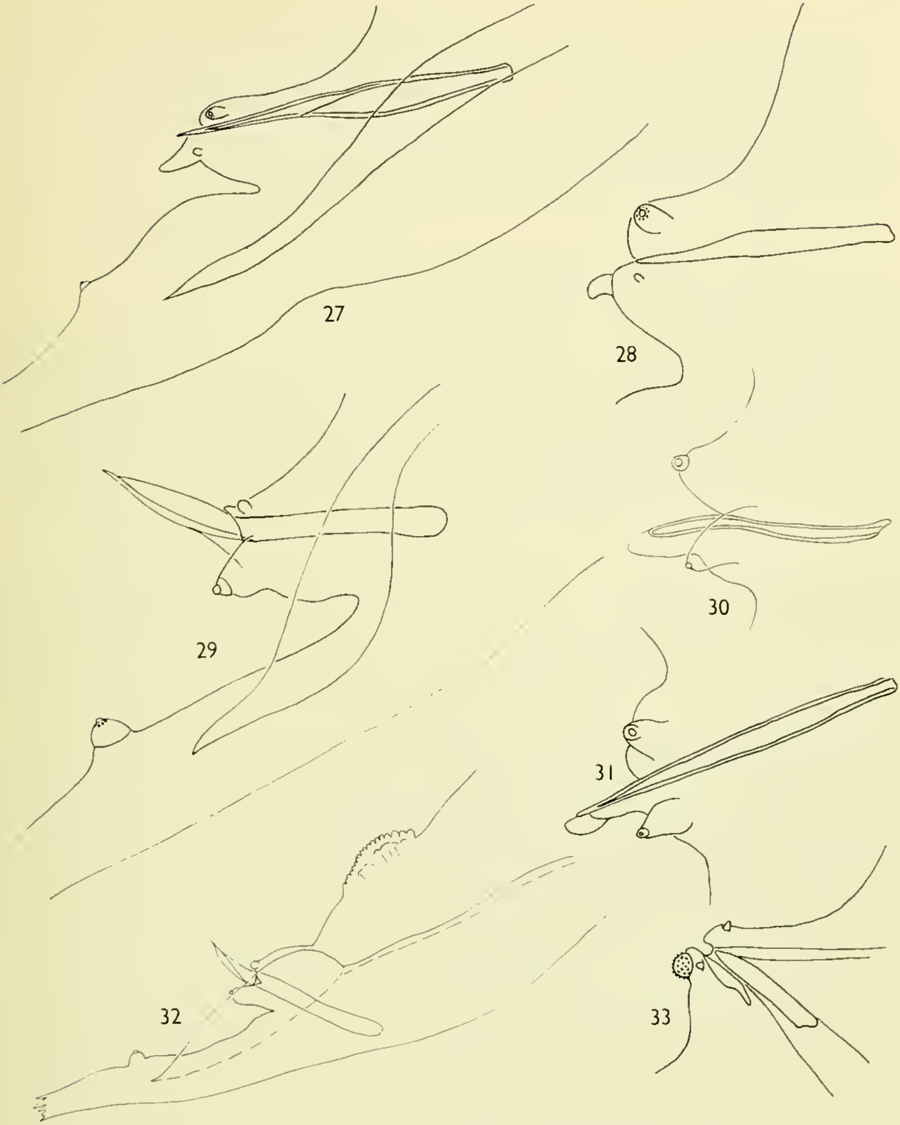
Parathelandros maini sp. nov.

(Text-figs. 10, 14, 24, 25, 26)

HOST AND LOCALITIES (all in Western Australia). *Hyla moorei:* swamp in Hardy Road, Cloverdale (Type host and locality); swamp in Hardy Road, Cannington; Nr. Garratt Road Bridge, Bayswater; Bolgonup Dam, Porongorup Range; Diannela, Perth; 21 mile peg on Mandurah Road, East Rockingham; 25 miles south west of Eneaba.

Hyla cyclorhyncha: Pine Hill, 13 miles north west from Mt. Ragged; Lake Condingup, 14 miles east of Esperance; Scadden.

Hyla adelaidensis: Pine Hill, 13 miles north west from Mt. Ragged.



FIGS. 27–33. 27, 28. *P. mastigurus:* 27. General lateral view of male tail. 28. Detail of cloacal cone from the lateral aspect. Note the small posterior pair of papillae and the flange-like post-cloacal lobe. 29. *P. carinae:* general lateral view of cloacal region. Note the large posterior pair of cloacal papillae. 30. *P. johnstoni:* detail of cloacal cone from lateral aspect. 31. *P. limnodynastes:* detail of cloacal cone from lateral aspect. Note the stouter spicule and the freestanding papillae in contrast to the condition shown in Fig. 30. 32. *P. carinae:* general view of posterior end of body showing the bursa-like modification of the alae and the pre-cloacal male swelling found on some specimens. 33. *P. australiensis:* detail of cloacal cone from lateral aspect.

This species is characterized by the excretory pore and vulva opening anterior to the posterior end of the oesophagus and by the possession of very wide lateral alae. The cloacal cone and papillae are small, with a smooth, rounded, ball-like post-cloacal lobe on which there appear to be two very small papillae. The post-cloacal papillae are rosette and arise from a common platform.

This species is most similar to *P. australiensis* from which it differs most markedly in the smooth post-cloacal lobe and the anterior position of the vulva.

Parathelandros propinqua (Johnston & Simpson, 1942) comb. nov.

Cosmocerca propinqua Johnston & Simpson, 1942.

Host and Locality. *Limnodynastes dorsalis*, Adelaide, South Australia (Type host and locality).

This species, in which the vulva opens anterior to the posterior end of the oesophagus, is known from females only. It is clearly referable to *Parathelandros* in which it could only be confused with *P. mastiguris* or *P. johnstoni*. No decision on its status can be taken until male specimens are collected from hosts in South Australia.

OTHER SPECIES REFERRED TO *PARATHELANDROS*

The following nine species have been referred to the genus *Parathelandros* at various times by various authors, thus: *Parathelandros anolis* Chitwood, 1934; *P. oedurae* Johnston & Mawson, 1947; *P. seclopori* Caballero, 1938 were all originally described as members of the genus. The following species have been referred secondarily to the genus: *Pharyngodon apappillosus* Koo, 1938 and *Ph. medina* Calvente, 1948 were referred to *Parathelandros* by Read & Amrein (1953) while Skrjabin *et al.* (1960) referred the following four species to the genus: *Ph. bassii* Walton, 1940; *Ph. mabuiensis* Malan, 1939; *Ph. mabuyae* Sandground, 1936 and *Oxyuris megalocerca* Skrjabin, 1916. None of these species possess the combination of characters considered diagnostic of *Parathelandros*, as restricted here.

Although it is easy to conclude that these species are not congeneric with the Australian species referred to *Parathelandros* it is difficult to know how to treat them, other than to leave them floating in limbo as species *incertae sedis*. This difficulty is a reflection of the general need for a revision of the subfamily Pharyngodoninae. Some attempt is made to carry out such a revision by Skrjabin *et al.* (1960) but they are hampered by their forced reliance on published descriptions many of which leave much to be desired. These authors regrouped some species previously referred to *Pharyngodon* in the genera *Spauligodon* and *Parathelandros*. The species they left in *Pharyngodon* have all the caudal papillae of the males surrounded by caudal alae; those referred to *Spauligodon* have the most posterior pair of papillae free of the caudal alae and those referred to *Parathelandros* have none of the caudal papillae surrounded by caudal alae.

This simple grouping breaks down with the discovery of so many morphological very similar species in Australian frogs in which the cloacal papillae arise from the cloacal cone. In the species grouped in *Parathelandros* by Skrjabin *et al.* (1960), with the exception of *P. mastiguris*, the cloacal papillae do not lie on such a cone, when present, but are grouped on the body surface around it. I shall, therefore, refer these latter species to a new genus *Skrjabinodon*. This is done mainly on grounds of expediency because the species concerned fall into two groups, and some of the species left in *Pharyngodon* by Skrjabin *et al.* do not appear to belong in that genus. In fact the delimitation of the groups represented by the genera *Pharyngodon*, *Spauligodon* and *Skrjabinodon* needs to be revised before any final judgement can be reached.

The genera may be diagnosed thus:

PARATHELANDROS Baylis, 1930

Oxyuridae: Pharyngodoninae: mouth opening bounded by three bilobed lips; small onchia in cavity at anterior end of oesophagus; lateral alae on both sexes; excretory pore and vulva variable in position from anterior to posterior end of oesophagus to posterior to oesophagus; tail terminates in long spike in both sexes. Male: spicule and poorly developed gubernaculum present; cloacal region raised as distinct cone; two pairs of papillae borne on cloacal cone; no caudal alae; pair of rosette papillae on tail, frequently arising from a common base.

TYPE SPECIES: *Parathelandros mastigurus* Baylis, 1930.

OTHER SPECIES: *P. australiensis* (Johnston & Simpson, 1942); *P. limnodynastes* (Johnston & Mawson, 1942); *P. maini* sp. nov.; *P. carinae* sp. nov.; *P. johnstoni* sp. nov.; *P. propinqua* (Johnston & Simpson, 1942).

HOSTS AND GEOGRAPHICAL DISTRIBUTION: Amphibia in Australia.

SKRJABINODON gen. nov.

Oxyuridae : Pharyngodoninae: mouth opening bounded by three (?) bilobed lips; no onchia at anterior end of oesophagus (?); lateral alae on both sexes frequently very narrow particularly in females; excretory pore and vulva generally about level of posterior end of oesophagus; tail terminates in long spike, in both sexes, frequently with barbs on female terminal spike; Male: spicule sometimes lacking; cloacal region raised as narrow elongate cone; two pairs of cloacal papillae which do not lie on cone; no caudal alae; one pair of post-cloacal papillae which frequently lie close to cloacal papillae; post-cloacal papillae not rosette and very prominent.

TYPE SPECIES: *Pharyngodon mabuyae* Sandground, 1936.

OTHER SPECIES: *S. anolis* (Chitwood, 1934); *S. apapillosus* (Koo, 1938); *S. mabuiensis* (Malan, 1939); *S. megalocerca* (Skrjabin, 1916); *S. oedurae* (Johnston & Mawson, 1947); *S. scelopori* (Caballero, 1938).

HOSTS AND GEOGRAPHICAL DISTRIBUTION: Reptiles in most regions of the world.

MEASUREMENTS FOR *PARATHELANDROS* SPECIES

These measurements are only intended to be indicative of the general range of size encountered. Many of the specimens were contracted, as is only natural with animals which depend upon an internal hydrostatic pressure to retain their shape, and most identification was carried out on morphological characters. All measurements are in mm., and in females the distance of the vulva only from the anterior end of the body is listed in some species where this is virtually the same as the distance of the excretory pore.

Parathelandros mastigurus

MALES. Body length: 1·36; 1·41; 1·43; 1·56. Body breadth: 0·094; 0·100; 0·098; 0·103. Oesophagus length: 0·26; 0·22; 0·26; 0·19. Distance of excretory pore from anterior end of body: 0·24; 0·19; 0·25; 0·16. Length of tail: 0·35; 0·33; 0·27 (broken at tip); 0·34. Length of spicule: 0·070; 0·069; 0·066; 0·070.

FEMALES. Body length: 3·38; 3·63; 3·67; 3·79. Body breadth: 0·32; 0·29; 0·30; 0·33. Oesophagus length: 0·51; 0·47; 0·50; 0·52. Distance of vulva from anterior end of body: 0·25; 0·21; 0·24; 0·25. Length of tail: 1·09; 0·91; 1·11; 1·12. Size of eggs: 0·139 × 0·043 and 0·132 × 0·041 (representative).

Parathelandros australiensis

MALES. Body length: 1·46; 1·76; 1·76. Body breadth: 0·15; 0·17; 0·18. Oesophagus length: 0·21; 0·22; 0·21. Distance of excretory pore from anterior end of body: 0·26; 0·30; 0·29. Length of tail: 0·53; 0·57; 0·59. Length of spicule: 0·031; 0·033; 0·030. Breadth of lateral alae: 0·046; 0·040; 0·046.

FEMALES. Body length: 5·12; 5·24; 5·33. Body breadth: 0·33, 0·34; 0·34. Oesophagus length: 0·37; 0·39; 0·42. Distance of vulva from anterior end of body: 0·43; 0·46; 0·49. Length of tail: 1·19; 1·26; 1·26. Size of eggs: 0·139 × 0·040 and 0·133 × 0·038 (representative).

Parathelandros limnodynastes

MALES. Body length: 2·04; 2·16; 2·19; 2·31; 2·38; 2·40. Body breadth: 0·23; 0·21; 0·23; 0·26; 0·27; 0·22. Oesophagus length: 0·35; 0·33; 0·33; 0·33; 0·34; 0·31. Distance of excretory pore from anterior end of body: 0·57; 0·43; 0·49; 0·55; 0·56; 0·61. Length of tail: 0·78; 0·62; 0·73; 0·82; 0·69; 0·66. Length of spicule: 0·084; 0·081; 0·074; 0·073; 0·083; 0·082.

FEMALES. Body length: 3·20; 3·32; 3·39; 3·42; 3·51; 4·29; 4·31. Body breadth: 0·31; 0·27; 0·31; 0·30; 0·31; 0·46; 0·42. Oesphagus length: 0·49; 0·53; 0·49; 0·52; 0·51; 0·57; 0·56. Distance of vulva from anterior end of body: 0·62; 0·73; 0·64; 0·67; 0·83; 0·63; 0·67. Length of tail: 0·53; 0·65; 0·57; 0·56; 0·59; 0·69; 0·78. Size of eggs: 0·102 × 0·036, 0·104 × 0·041 and 0·079 × 0·030 (representative).

Parathelandros johnstoni

MALES. Body length: 1·21; 1·67; 1·94; 1·99; 2·20; 3·13; 3·17. Body breadth: 0·22; 0·21; 0·19; 0·24; 0·23; 0·23; 0·31; 0·35. Oesophagus length: 0·39; 0·37; 0·36; 0·38; 0·40; 0·43; 0·44; 0·44. Distance of excretory pore from anterior end of body: 0·43; 0·43; 0·45; 0·46; 0·48; 0·51; 0·66; 0·63. Length of tail: 0·72; 0·66; 0·67; 0·65; 0·69; 0·74; 0·82; 0·83. Length of spicule: 0·063; 0·064; 0·064; 0·065; 0·068; 0·068; 0·078; 0·073. Breadth of lateral alae: 0·039–0·047.

Females. (first four specimens are either immature or early gravid). Body length: 3·91; 3·98; 4·38; 4·47; 4·72; 6·36; 7·20; 7·54; 8·56; 8·97. Body breadth: 0·31; 0·29; 0·35; 0·33; 0·33; 0·38; 0·34; 0·39; 0·46; 0·44. Oesophagus length: 0·64; 0·64; 0·74; 0·62; 0·60; 0·69; 0·66; 0·69; 0·64. Distance of vulva from anterior end of body: 0·99; 0·98; 0·99; 1·09; 0·91; 1·00; 0·93; 1·04; 0·99; 1·17. Length of tail: 0·52; 0·60; 0·62; 0·71; 0·98; 1·24; 1·14; 1·19; 1·34; 1·31. Size of eggs: 0·112 × 0·033 and 0·116 × 0·036 (representative). Breadth of lateral alae: 0·025–0·028.

Parathelandros carinae (N.B. vulva and excretory pore measurements differ)

Males. Body length: 0·91; 1·14; 1·26; 1·38; 1·48; 1·64; 1·92. Body breadth: 0·078; 0·12; 0·13; 0·14; 0·11; 0·12; 0·18. Oesophagus length: 0·25; 0·28; 0·44; 0·33; 0·39; 0·40; 0·45. Distance of excretory pore from anterior end of body: 0·28; 0·35; 0·52; 0·39; 0·49; 0·52; 0·43. Length of tail: 0·22; 0·28; 0·27; 0·26; 0·34; 0·34; 0·33. Length of spicule: 0·073; 0·096; 0·094; 0·095; 0·072; 0·073; 0·089.

Females. Body length: 2·17; 2·22; 3·89; 4·51; 4·94; 7·66; 7·92. Body breadth: 0·21; 0·18; 0·25; 0·29; 0·26; 0·46; 0·43. Oesophagus length: 0·46; 0·42; 0·55; 0·55; 0·53; 0·70; 0·73. Distance of vulva from anterior end of body: 0·85; 0·87; 1·21; 1·12; 1·22; 1·24; 1·12. Distance of excretory pore from anterior end of body: 0·54; 0·54; 0·81; 0·81; 0·94; 0·80; 0·97. Length of tail: 0·55; 0·53; 1·00; 0·97; 1·04; 1·24; 1·48. Size of eggs: 0·152 × 0·046.

Parathelandros maini

Males. Body length: 1·20; 1·52; 1·67; 1·95; 2·07; 2·07. Body breadth: 0·092; 0·13; 0·12; 0·22; 0·24; 0·23. Oesophagus length: 0·26; 0·30; 0·28; 0·30; 0·30; 0·32. Distance of excretory pore from anterior end of body: 0·21; 0·27; 0·24; 0·28; 0·29; 0·26. Length of tail: 0·43; 0·45; 0·49; 0·59; 0·53; 0·55. Length of spicule: none seen; 0·039; none seen; 0·042; 0·054.

Females. Body length: 4·21; 4·41; 4·50; 5·12; 6·63; 7·48. Body breadth: 0·25; 0·29; 0·26; 0·29; 0·44; 0·38. Oesophagus length: 0·52; 0·55; 0·49; 0·55; 0·55; 0·59. Distance of excretory pore from anterior end of body: 0·35; 0·22; 0·31; 0·42; 0·40; 0·45. Distance of vulva from anterior end of body: 0·38; 0·25; 0·35; 0·46; 0·44; 0·48. Length of tail: 0·96; 1·16; 0·98; 0·96; 0·98; 1·07. Size of eggs: 0·135 × 0·046 and 0·122 × 0·040 (representative).

ACKNOWLEDGEMENTS

The work reported on here was largely carried out while Exchange Curator in the Western Australia between March, 1966 and April, 1967. Thanks are due to all the staff of that Museum for making my stay enjoyable and for the help they gave me in various ways; in particular to Miss C. M. Chambers, (now Mrs. Martin) who acted as my assistant, and to Dr. G. M. Storr who allowed me to remove parasites from some of the frogs under his charge.

Thanks are also due to Professor A. R. Main of the Department of Zoology, University of Western Australia for making available to me many of the specimens he had collected during his studies on the frogs of Western Australia; to Mr. Barry Muir of the same Department who collected so many live frogs during my period in Perth; to Professor H. G. Andrewartha, Department of Zoology, University of Adelaide who allowed me to work in his Department on two occasions; and finally I would express my particular appreciation to Mrs. P. M. Thomas of the University of Adelaide who not only looked after me so very well while in Adelaide, but also sent me specimens to study in London after my return from Western Australia.

Parathelandros maini is named in appreciation of the help received from Professor Main; *P. johnstoni* is named for the late Professor T. Harvey Johnston at whose instigation and upon whose encouragement so much of our knowledge of Australian helminths has depended; finally *P. carinae* is named for Miss Carina Wilson, whose father is Curator of Molluscs in the Western Australian Museum, as it was first recognized on the occasion of her sixth birthday.

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